Life-cycle Energy Assessment of Alternative Water Supply Systems in California

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The Issue

The California Energy Commission has determined that one-third of California's electricity is used by industry, agriculture, and water and wastewater utilities. Drinking water availability is diminishing while demand increases. Promising alternatives for processing and delivering water will require more energy than those currently in place. The additional energy may create various environmental effects, including air emissions.

Properly planning for water supply, while considering energy and emissions implications, requires life-cycle assessment (LCA) of potential water supply systems. Life-cycle assessment is a systematic, quantitative approach for evaluating the impacts of a product or process holistically. It considers all energy and environmental implications of processes through the entire life cycle, including design, planning, material extraction and production, manufacturing or construction, use, maintenance, and end-of-life (reuse, recycling, or landfilling). It targets energy-reduction efforts and informs water supply planning.

Project Description

The researchers studied alternative water sources in California, including importing, recycling, and desalinating water, to determine the life-cycle energy and environmental effects of the associated infrastructure. LCA was used to quantify the energy and environmental emissions associated with water system infrastructure from different life-cycle phases (construction, operation, maintenance), water supply phases (supply, treatment, distribution), and water sources (imported, recycled, and desalinated water).

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Providing environmentally sound and affordable energy services.** This research provides vital information for California water utilities as they decide how to best provide water to their customers in the most cost-efficient and sustainable way. The results can help these utilities reduce their electricity use and subsequent costs and environmental effects. In

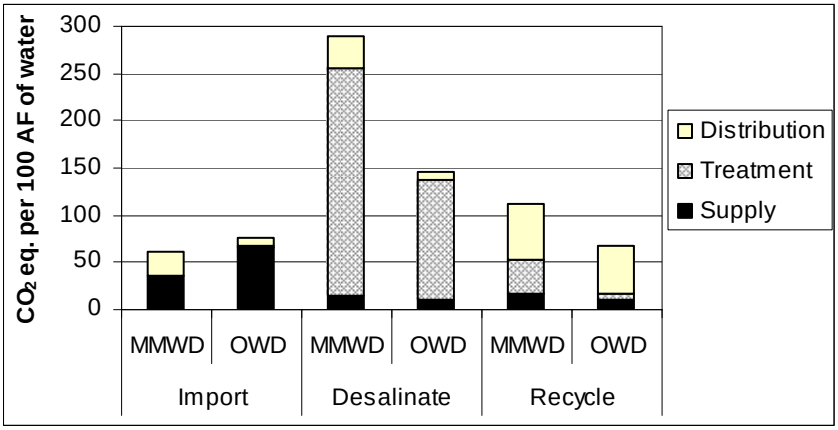
addition, the research identifies where efforts should be focused to reduce energy use further up the water system supply chain.

Results

An LCA was used as the basis for creating a decision support tool, the Water-Energy Sustainability Tool (WEST). WEST evaluates the life-cycle energy and environmental effects of water systems, specifically those caused by material production and delivery, equipment operation, and energy production.

To test its capabilities, WEST was used to evaluate the environmental effects of water supplied by importing, desalinating, and recycling water by two case study utilities: the Marin Municipal Water District (MMWD) and the Oceanside Water Department (OWD). Though the effects of other water supply systems will be affected by site-specific details (e.g., topography, system scale, treatment process), the results of these case studies provide insight into the life-cycle effects of California water systems.

This research determined the energy use and emission factors for global warming potential (GWP) and certain air emissions for the case study systems. The results showed that desalination creates the majority of emissions in all categories. Desalination in the MMWD system, which uses a seawater source, is more environmentally detrimental than the OWD's brackish groundwater system. The MMWD recycled water system also produces more environmental effects because it has a more complex treatment and distribution system. Imported water provisions for the systems create comparable environmental effects. The results for GWP attributable to each water supply phase are illustrated in the figure below, which shows that most of the imported water emissions occur in the supply phase. Desalination is dominated by treatment; recycling, by distribution.



Global Warming Potential of Water Supply Alternatives by Water Supply Phase

This research provides groundwork for future research on water system energy use by identifying the processes that are most energy- and pollution-intensive in the water supply life-cycle. Further, the research creates a methodology that can be used to analyze other water and wastewater planning decisions. This information can be used to target future research in areas where improvements can be made most readily.

Final Report

The final report of this research, *Life-cycle Energy Assessment of Alternative Water Supply Systems in California* (CEC-500-2005-101), is available on the California Energy Commission's website, at www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-101.html.

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